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Importance of Capsule Surface Smoothness Validated by High Convergence OMEGA Indirect-Drive Implosions

We have recently concluded an extended study of the effects of capsule surface roughness on implosion performance in indirectly driven capsules. Understanding effects of capsule surface roughness is important because surface defects are amplified during an implosion by the Rayleigh-Taylor instability and result in degraded implosion performance due to mixing of capsule material into the hot deuterium fuel. Using integrated simulations and an atomic mix model, we are able to match the observed capsule performance over a range of surface roughness.

These experiments were performed on the OMEGA laser at the University of Rochester. We used a well-characterized, reproducible hohlraum, capsule, and laser beam geometry to assess the effect of surface roughness on imploded capsule performance. The hohlraums were gold cylinders (2.5 mm long, 1.6 mm diameter). To study the effects of surface roughness, these experiments used capsules that were deliberately roughened by a laser-ablation technique. Capsules were fabricated from germanium-doped (1% atomic fraction) plastic (CH), with approximately 440-μm inner diameters and 30-μm-thick walls, and filled with 10 atm of deuterium. Surfaces were characterized by a rotary Atomic Force Microscope, and simulations used the full spectrum of measured surface modes. In Figure 1, the modes are summed to produce a single rms number for comparison to the data.

To assess implosion performance, we measured neutron yield, and the shape of the x-ray emitting imploded core to ensure adequate implosion symmetry. The illumination symmetry allowed for symmetric implosions up to a convergence factor of 18, 2x greater than for previous Nova implosions [1]. The pulse shape is shown in Figure 1 for a number of shots, showing good reproducibility from shot to shot.

The experimental and calculated yields are shown in Figure 2. Both integrated simulations without mix ("clean") and including "mix" are shown for each shot. The simulated yields, including mix, match the data within better than a factor of two over more than an order of magnitude variation in surface roughness and yields. Future experiments will compare the sensitivity to roughness of other candidate capsule ablators such as Cu-doped beryllium and diamond using the same hohlraum drive.

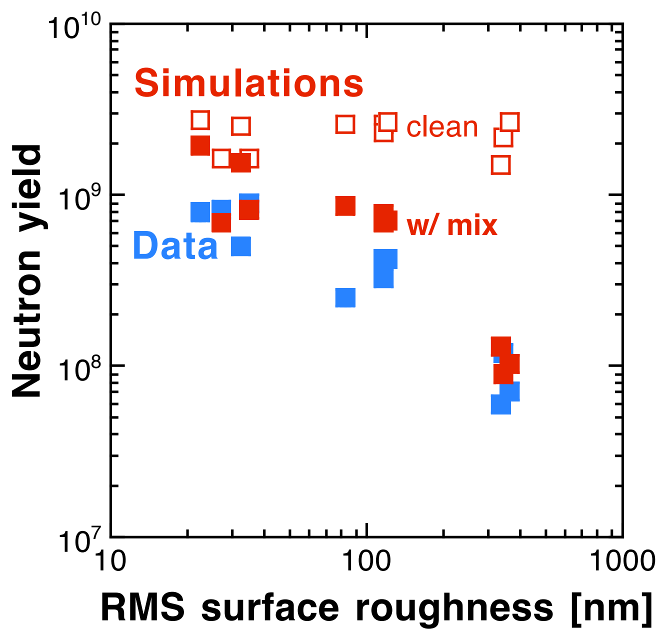
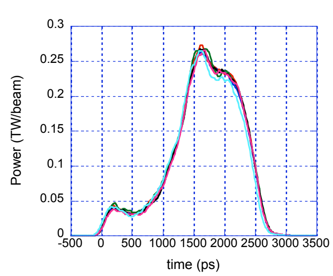


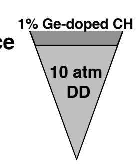
Figure 2. Neutron yield data and simulations with and without mix, plotted against single-number characterization of capsule surface roughness.

A series of integrated experiments is assessing capsule performance vs surface smoothness

- **High-performance pulse-shape "PS26" with 5:1 contrast**



- **High-convergence "HEP5" capsules**



- **Surface roughness measured with AFM along several circumferential traces and characterized by a single number:**

$$RMS \equiv 10 \cdot a_{10} + \sqrt{\sum_{\ell=11}^{\infty} a_\ell^2}$$

- **Simulations use all modal content above mode number $\ell = 9$**

Figure 1. The pulse shape shown in upper right was highly reproducible from shot to shot.

[1} Marinak et al., *Phys. Plasmas* 3 (1996) 2070.

For comments about content of the ***Bimonthly Update***, contact Bruce A. Hammel (925) 422-3299.
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